Development and large scale violence

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Abstract. A single equation model is inadequate to capture the various transmission channels linking civil war to per-capita income. Therefore, this paper uses a system of four equations to estimate the economic cost of civil conflict. In the system, conflict is allowed to affect per-capita income both directly and indirectly through its effect on a set of "deep determinants" of income. Estimates indicate that the income loss associated with conflict is economically sizeable and that slightly less than half of this loss arises from the deterioration of institutions. Eventually, the economy rebounds, recovering about one half of the initial loss.

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1. Introduction

The analysis of the economic costs of large scale and organized violence is a lively area of research, as the recent surveys of Blattman and Miguel (2010), Bozzoli et al. (2010), and Skaperdas (2011) clearly suggest. From an empirical perspective, three main methodological approaches have been explored.[1] A first group of papers makes use of accounting methods to compute the direct cost of violence; that is, the budgetary cost, such as the increase in military expenditure and the decrease in taxation, or the cost of the destroyed infrastructures (Bruck 2001, Fitzgerald et al. 2001, and Collier et al. 2003). In order to provide a more comprehensive estimate of indirect costs, including the loss of economic growth and income, a second group of papers compares the actual performance of countries afflicted by conflict against a counterfactual performance derived from similar, non-conflict, countries (Stewart et al. 2001) or artificially constructed benchmarks (Abadie and Gardeazabal, 2003). A related approach exploits events such as cease-fires and truces in war-torn countries to construct natural experiments and analyze how the dynamics of relevant macro variables differ between times of violence and times of peace (Abadie and Gardeazabal, 2003 and Chen et al. 2007). Finally, a third group of papers employs standard regression analysis to estimate the marginal effect of the frequency and intensity of violence on the economic variables of interest, such as growth, income, and physical or human capital (Abadie and Gardeazabal, 2008, Collier 1999, Blomberg et al. 2004, Cerra and Saxena, 2008, Miguel and Roland, 2006, and Lopez and Wodon, 2005). This paper fits within this third group. Its main contribution is to extend the conventional analysis, based on a reduced-form equation, by estimating a system of equations that model different transmission channels.

More specifically, the existing evidence from regression analysis is typically based on the

[1] For a detailed technical review of the methods for measuring the aggregate costs of conflict see Gardeazabal (2010).

estimation of the following single equation model:

$$y_{it} = \beta w_{it} + \boldsymbol{\gamma}'\mathbf{z}_{it} + \varepsilon_{it} \tag{1}$$

where y is the variable of interest (the level or the growth rate of per-capita GDP in most applications), w is a proxy for violence, $\mathbf{z} = [z_1, z_2, ...z_s]$ is a set of controls (including a constant term), ε is an error term, i is a generic country, t denotes time, and β and $\boldsymbol{\gamma} = [\gamma_1, \gamma_2 ... \gamma_s]$ are the parameters to be estimated. The estimation of a regression of this type faces two complications. One is that violence is most likely endogenous to income (or growth). The other is that violence potentially affects several of the controls in $\mathbf{z}$. Some important progress in the treatment of the endogeneity has been recently made by Yamarik et al. (2010). The second complication instead has been systematically neglected. The problem is that if violence affects y through its effect on $\mathbf{z}$, then the parameter β only captures the "residual" direct effect of violence and not its full economic cost. A possible solution (see for instance Collier, 1999) is to exclude from equation (1) those controls that are likely to account for the transmission of the effect of violence. This, however, might lead to omitted variables and hence biased estimates.

A more appropriate modelling strategy is to represent the set of structural relations that link violence to income and its determinants using a system of equations. To this purpose, the paper estimates a system of the following general form:[2]

$$g_{j,it} = \boldsymbol{\alpha}'_j \mathbf{x}_{j,it} + \epsilon_{j,it} \tag{2}$$

[2] While there are several examples of applications of system estimation to macro-development issues (see, inter alia, Lundberg and Squire, 2003; Imbs, 2004; Carmignani, 2008 and 2011; Huang et al. 2009), to the best of author's knowledge only Gupta et al. 2004 explore the system approach to study the effects of war. However, their paper focuses on one channel of transmission only (fiscal policy) and does not tackle the issue of endogeneity.

where $j = 1...m$ is an index that denotes variables and parameters in the j^{th} equation and M is the total number of equations in the system, g_j, $\mathbf{x}_j$, and ϵ_j are the dependent variable, the set of regressors, and the error term in the j^{th} equation, respectively, i indexes countries and t is the time index as before, $\boldsymbol{\alpha}_j$ are the parameters to be estimated, and $E[\epsilon_{j,it}, \epsilon_{l,it}] \neq 0$ for $j \neq l$. The system consists of four equations (i.e. $M = 4$). The four dependent variables are per-capita income and three of its "deep determinants", namely trade integration, education, and institutional quality (a fourth deep determinant, geography, is included as a regressor, but treated as exogenous). While $\mathbf{x}_j$ differs across equations, the proxy for violence w is included as a regressor in each equation. In this way, w is allowed to affect per-capita income both directly and indirectly through its effect on the other deep determinants.

Large scale violence comes in different forms, including internal and international conflict and terrorism. The focus of this paper is on civil war, defined as an armed conflict that involves military action internal to the metropole, with active participation of the national government, an effective resistance by both sides, and at least 25 battle related deaths a year including military personnel and civilians. The frequency of occurrence of this type of organized violence has increased significantly through the last six decades. The Uppsala/PRIO Armed Conflict Dataset[3] lists 265 civil wars since the end of World War II, 111 of which involved more than 1000 battle related deaths. Fearon and Laitin (2003) report that the death toll of civil wars is at least five times as large as the death toll of interstate wars. About half of all nations have been afflicted by at least one civil war and more than 70 nations have suffered a civil war with more than 1000 battle related deaths a year. Most of these war-torn countries are developing economies and civil war has indeed been often

[3] This is one of the most popular conflict datasets, jointly provided by the Uppsala Conflict Data Program and the International Peace Research Institute, Oslo. See Gleditsch et al. (2002).

indicated as the main constraint on development and poverty reduction (see Rodrik, 1999 and World Bank, 2011)[4] . The question of how civil war affects income and development is therefore not just academically pertinent, but also relevant from a policymaking perspective.

The estimation results indicate that civil war negatively affects per-capita income both directly and indirectly via the disruption of institutions. Civil war also reduces international trade integration, but trade does not significantly affect per-capita income after controlling for other determinants. Conversely, schooling appears to be a determinant of per-capita income, but it is not significantly affected by civil war. Quantitatively, the marginal effect of civil war is quite large: one year of war (causing 1000 battle related deaths) in a given quinquennium t reduces average per-capita income in that quinquennium by approximately 15% (the exact percentage depending on which regression model is used as the benchmark for calculations). The transmission via institutions accounts for at most one half of this income loss, while the rest is the residual direct effect after controlling for other possible transmission channels. These negative effects, however, are not strongly persistent and the economy seems to rebound already in the subsequent quinquennium $t + 1$. The cumulated effect in quinquennium $t + 2$ is still negative, but significantly smaller than the contemporaneous effect in quinquennium t. Finally, contrary to some recent evidence, the spatial dimension of civil conflict does not seem to be particularly relevant here; that is, conflicts occurring in neighbor countries do not significantly worsen domestic per-capita income or its deep determinants.

The rest of the paper is organized as follows. Section 2 introduces the modelling strategy. Sections 3 and 4 presents the estimation results. Section 5 concludes. Definitions, sources, and summary statistics are provided in the Appendix.

[4] Carmignani and Gauci (2010) document a very strong negative correlation between occurrence of civil war and the Human Development Index ranking.

2. Modelling strategy

2.1 Theoretical premise

In this paper, the cost of civil war is represented by a decrease in the level of per-capita income. The focus is on the level rather than the growth rate of per-capita income because, as noted by Hall and Jones (1999), the level more than the growth rate captures the differences in long-run economic performance that most directly relate to welfare as measured by consumption of goods and services[5] . A theory of how civil war is going to affect the level of per-capita income is therefore necessary to inform the econometric modelling strategy. In particular, such a theory should provide guidance on (i) how to represent the determinants of per-capita income and (ii) how civil war might impact on these determinants.

From a theoretical standpoint, the simplest description of per-capita income is probably a neoclassical production function of the type $y = f(A, k)$, where y is per-capita income, k is per-capita physical capital, A is the level of technology, and $f(\cdot)$ is a continuous concave function with standard neoclassical properties. This description leads to an accounting decomposition where differences in per-capita income across countries (and/or over time) are due to differences in per-capita physical capital and differences in the level of productivity. So, physical capital and productivity can be seen as the "proximate" determinants of per-capita income. However, the econometric model ought to focus on the representation of the "deep" determinants of per-capita income; that is, those factors that drive the differences in the proximate determinants.

While there are certainly many candidates, the deep determinants that most often recur in the existing literature are: geography, institutions, trade integration, and education.

[5] This focus on level is now well established in the applied macroeconomic literature, see for instance, Acemoglu et al. (2001), Rodrik et al. (2004), Glaeser et al. (2004), Nunn (2008), Battacharrya, (2009), and Alexeev and Conrad (2009).

Their role as potential drivers of income and development has been widely investigated in previous work.[6] In a nutshell, a more favorable geography, better institutions, greater economic integration, and a more educated population should all contribute to increasing per-capita income. Geography determines natural resource endowments, quality of soil, climate, and disease environment. These factors are then linked to income through multiple channels. For instance, natural resources are a potential source of income, but their abundance can crowd-out investment in other sectors and in education. The quality of soil and the climate influence the productivity of land, while the disease environment affects the productivity of labour. Institutions determine agents' incentive to participate in economic activities (i.e. investing, producing, consuming) by setting the context within which economic interactions take place. Economic integration affects the extent to which a country can benefit from knowledge spillovers, externalities, and capital inflows. Finally, education produces significant externalities in terms of more benign politics and a better quality of the labour force.

Given a representation of per-capita income as a function of the deep determinants, the next step is to consider how civil war might affect these determinants. Geography is generally regarded as exogenous and therefore independent from civil war. In fact, while international armed conflict might impact on country's land area or access to the sea, internal conflict is unlikely to have a significant effect on most geographical characteristics. Conversely, there are solid reasons to believe that civil war influences the other three deep determinants. Internal conflict hinders trade routes, disrupts infrastructures, and creates uncertainty and insecurity, thus scaring away international trade partners and investors. Its negative effects on trade and capital flows are therefore potentially very large.[7] A civil war also causes

[6] See for instance Rodrik (2002), Rodrik et al. (2004) and Glaeser et al. (2004)

[7] There is a large body of research that studies the effect of international conflict on trade and integration (see Glick and Taylor 2010 for a recent contribution). Specific evidence on the negative effect of internal

the government to lose its legitimacy, thus exacerbating political and social divisions, and ultimately resulting in the disintegration of domestic institutions.[8] In times of civil conflict, the revenues of the government decline while more resources are needed to finance military expenditure. This in turn leads to a large reduction in the supply of public goods, including education. Moreover, disruption of public education infrastructures and the injuries and deaths to educators further contribute to lowering the rate of human capital accumulation. All in all, civil war is expected to lower per-capita income by adversely affecting institutional quality, trade integration, and/or education.

Two additional considerations complete this theoretical premise. One concerns the possible interrelations between deep determinants. More specifically, geographical factors may influence trade integration, institutional quality, and education. For instance, geographical distance and physical connectivity reduce economic integration regardless of a country's trade policy. A bad disease environment might have prevented colonizers from settling down, thus leading to the creation of extractive, low quality, institutions that have then persisted until today (see also Subsection 2.4). Resource abundance may discourage human capital accumulation by causing the economy to overdepend on the resource sector, which is not intensive in skilled labour and therefore does not offer high returns to investment in education. The second relevant consideration is the possibility that civil war affects per-capita income directly; that is, not just via its impact on institutional quality, education, or trade integration. A candidate explanation for this direct effect is that civil war disrupts infrastructures and equipment (that is, physical capital), thus compromising the production process and distorting the allocation of inputs. In this sense, civil war could directly affect

conflict on international trade is provided by Rupert (2004) and Magee and Massoud (2011)

[8] On the adverse effects of civil war on the social fabric, see, inter alia, World Bank (2003). The views in the literature are not unanimous and some papers suggest that civil wars might lead to state-building and greater political mobilization. See for instance Bellows and Miguel (2006). In this case, the institutional channel would transmit a positive effect of war on income.

the proximate determinants of income.

This theoretical premise gives rise to the following set of structural relations:

$$y = f_y(p, k, q, \mathbf{h}_y, w) \tag{3}$$

$$\begin{bmatrix} p \\ k \\ q \end{bmatrix} = \begin{bmatrix} f_p(\mathbf{h}_p, \mathbf{c}_p) \\ f_k(\mathbf{h}_k, \mathbf{c}_k) \\ f_q(\mathbf{h}_q, \mathbf{c}_q) \end{bmatrix} + w \tag{4}$$

where y is per-capita income, p denotes economic integration with the rest of the world, q is institutional quality, k is education, $\mathbf{h}$ is a vector of geographical characteristics $\mathbf{h}_j$ and $\mathbf{c}_j$ are sets of geographical variables and other exogenous regressors, respectively, in equation j $(j = y, p, k, q)$, w denotes war, $f_j(\cdot)$ is a continuous, differentiable function. The key theoretical predictions can then be stated in terms of the sign of the partial derivatives:

$$\frac{\partial f_y(\cdot)}{\partial p} > 0, \frac{\partial f_y(\cdot)}{\partial k} > 0, \frac{\partial f_y(\cdot)}{\partial q} > 0, \frac{\partial f_y(\cdot)}{\partial w} < 0 \tag{5}$$

$$\frac{\partial f_p(\cdot)}{\partial w} < 0, \frac{\partial f_k(\cdot)}{\partial w} < 0, \frac{\partial f_q(\cdot)}{\partial w} < 0 \tag{6}$$

The positive sign of the derivatives in (5) reflects the view that per-capita income should positively depend on economic integration, human capital accumulation, and institutional quality (after accounting for the impact of geography). The negative sign of the derivatives in (6) follows from the argument that civil war disrupts integration, human capital, and institutions (again, after controlling for the impact of geography and other possible determinants of p, k, and q). The three transmission channels of the effect of w on y through p, k, and q are therefore expected to work in the same direction as the direct effect, leading to the unambiguous prediction that the aggregate effect of civil war on per-capita income is negative.

2.2 Econometric model

The econometric representation of the structural equations (3) and (4) is as follows:

$$y_{it} = \alpha + \sum_{r=0}^{R} \beta_r w_{it-r} + \mathbf{z}'_{it}\boldsymbol{\gamma} + \mathbf{x}'_{y,it}\boldsymbol{\delta}_q + \varepsilon_{it} \tag{7}$$

$$q_{it} = \eta_q + \sum_{r=0}^{R} \theta_{q,r} w_{it-r} + \mathbf{x}'_{q,it}\boldsymbol{\delta}_q + \epsilon_{q,it} \tag{8}$$

$$k_{it} = \eta_k + \sum_{r=0}^{R} \theta_{k,r} w_{it-r} + \mathbf{x}'_{k,it}\boldsymbol{\delta}_k + \epsilon_{k,it} \tag{9}$$

$$p_{it} = \eta_p + \sum_{r=0}^{R} \theta_{p,r} w_{it-r} + \mathbf{x}'_{p,it}\boldsymbol{\delta}_p + \epsilon_{p,it} \tag{10}$$

where i denotes country and t time, y, q, k, p are the empirical proxies for, respectively, per-capita income, institutional quality, education, and integration, w is the empirical proxy for civil conflict, $\mathbf{z} = [q, k, p]$, $\mathbf{x}_y$, $\mathbf{x}_q$, $\mathbf{x}_k$, and $\mathbf{x}_p$ are vectors of geographical variables and other exogenous controls, ε, ϵ_q, ϵ_k, and ϵ_p are error terms, and α, β, η_q, η_k, η_p, θ_q, θ_k, θ_p, $\boldsymbol{\gamma}$, $\boldsymbol{\delta}_q$, $\boldsymbol{\delta}_k$, and $\boldsymbol{\delta}_p$ are the parameters to be estimated. Equation (7) expresses per-capita income as a function of its deep determinants. The other equations allow civil war to affect per-capita income via its effect on the deep determinants. The inclusion of w directly as a regressor in equation (7) is meant to capture the residual effect of civil war on per-capita income after controlling for the transmission via institutional quality, education, and trade integration.

This empirical specification adds an important element to the set of structural relations discussed in Subsection 2.1. For $r > 0$, civil war is allowed to affect per-capita income and its deep determinants with a lag. While the theoretical arguments previously discussed are essentially static, the effects of civil war are likely to be dynamic in the sense that they extend beyond the period when the conflict occurs. The cumulated effect (F) of civil war on per-capita income is then equal to:

$$F = \sum_{r=0}^{R} \beta_r + \gamma_q \sum_{r=0}^{R} \theta_{q,r} + \gamma_k \sum_{r=0}^{R} \theta_{k,r} + \gamma_p \sum_{r=0}^{R} \theta_{p,r} \tag{11}$$

where γ_q, γ_k, and γ_p are the coefficients of q, k, and p in equation (7).

2.3 Estimation and data issues

Equations (7), (8), (9), and (10) can be estimated either separately equation-by-equation or jointly as a system. By allowing the errors across equations to be correlated, the system approach should produce more efficient estimates. However, if one of the equations in the system is misspecified, then the other equations will also be affected. Given that it is difficult to establish unambiguously the superiority of one approach over the other, it is probably best to use both and see how results change. Accordingly, the four equations are first estimated individually by 2SLS and then jointly by GMM.

Estimates are based on a panel of 85 countries over the period 1960-2005. Data are averaged over sub-periods of five years, so that there are at most nine observations per country, even though the panel is unbalanced. This panel structure has some important advantages over a pure cross-section. For instance, with the panel it is possible to assess the impact of civil war at different lags. At the same time, the focus of the paper on development effects makes annual data rather unattractive as they tend to incorporate significant short-term noise. Five year averages therefore represent a compromise between the need to have a time series dimension (in addition to the cross-section dimension) and the need to smooth away short-term fluctuations to focus on medium-long term effects.[9]

The empirical proxy for per-capita income is (the log of) per-capita GDP. Institutional quality is measured by the ratio of non-currency money to the total money supply. This ratio is an indicator of the enforceability of contracts and the security of property rights (see Clague et al. 1999) that has two important advantages over other popular measures of institutions. First, it is an objective (as opposed to subjective) indicator. Second, it can be easily constructed for long time periods and for most countries. Education is proxied by the total years of formal schooling of the average individual in the population (Barro and Lee, 2010). Finally, trade integration is measured by the ratio of exports plus imports to total GDP (Rodrik et al. 2004).

The civil war variable w is defined as the number of years of civil war in country i in quinquennium t weighed by the corresponding battle related deaths (in thousands of casualties). Combining duration and intensity in the same measure is important because the two dimensions are not necessarily always correlated. For instance, the three year civil war between the Ethiopian government and the EPRDF military faction (1989-1991) caused an estimated 41901 battle related deaths. Around the same period, there were civil wars in Georgia and Haiti that also lasted for three years, but which only caused an estimated 303 and 492 battle related deaths respectively. If the variable w were only coded in terms of duration, then the Ethiopian civil war would have the same intensity as the Georgian and Haitian wars, even though it caused 40000 deaths more and was therefore much more disruptive. The data on duration and battle deaths needed to construct the war variable are

[9] Admittedly, there is not a strong argument to prefer five year averages to, say, ten year averages. Albeit quantitatively different from those reported in this paper, the results obtained with ten year averages tell a qualitatively similar story.

taken from the Uppsula/PRIO armed conflict dataset (see Gleditsch et al. 2002).[10]

2.4 Identification and specification tests

To deal with the endogeneity issue, suitable instruments for the civil war variable must be identified. While the instrumentation of income in regressions where war is the dependent variable has been systematically addressed in recent contributions (Miguel et al. 2004, Ciccone, 2008, Besley and Persson, 2008), the instrumentation of civil war in income regressions is still quite an unexplored territory. Yamarik et al. (2010) devise an identification strategy that uses geographic, historical and political factors as the sources of exogenous variation in the probability of conflict. In fact, geographical factors appear to be a particularly promising instrument: they are most likely to be exogenous to economic outcomes and there is now growing evidence that they do play a significant role in explaining the likelihood of conflict (see Fearon and Laitin, 2003). More specifically, factors like a rough terrain, a wide land area, and the presence of a territorial base separated from the state's center by a physical barrier (i.e. water or distance) are all factors that should increase the likelihood and duration of a civil war as they make it easier for rebels to hide and more difficult for the government to patrol, control, and prevent rebellious activities. Drawing on these arguments, three candidate instruments are considered: (i) the variable *non contiguous* is a dummy that takes the value of one if the state has a non-contiguous territory and zero otherwise, (ii) *elevation difference* measures the difference (in meters) between the highest and the lowest points of a state, and (iii) *land area* is simply (the log of) the area of a country, expressed in km^2.

In fact, in addition to civil war, the deep determinants p, q,and k in equation (7) may also

[10] An alternative data source is the Correlates of War (COW) project (see Singer and Small, 1994). The correlation between the war variable coded from the Uppsula/PRIO database and the war variable coded from the COW project is 0.89. For a discussion on the main sources of data and correlation coefficients across datasets, see Sambanis (2004).

be endogenous to y due to measurement errors, omitted variables, or even reverse causality. These variables are then instrumented as follows. Starting with institutional quality, a first possible instrument comes from the work of La Porta et al. (1999). They argue that the legal tradition of a country significantly affects the balance of power between the individuals and the State, thus determining the degree of protection of citizens' economic rights against the interference of the government. This suggests instrumenting institutional quality with a set of dummy variables that capture differences in legal origins. Alternatively, Acemoglu et al. (2001) develop a theory of institutions that links the quality of current institutions to the disease environment and the mortality rate of the colonizers. In countries where the disease environment was particularly difficult, high mortality induced colonizers not to settle down, which in turn meant that they had no interest to establish good institutions. Conversely, in countries with a favorable disease environment, colonizers decided to settle down and therefore tried to reproduce the (good) institutions they had back home. Colonial institutions have then persisted over time, meaning that in countries with a worse disease environment institutions are of a poorer quality. This theory provides two candidate instruments: the rate of settler's mortality and the quality of the disease environment, which can be proxied by the malaria ecology indicator discussed in Sachs (2003). It turns out that of all these possible instruments, malaria ecology has indeed the strongest statistical performance.

Trade integration is instrumented by a measure of country $i's$ remoteness. This measure of remoteness is computed as the weighted average of the log of the bilateral distance between country i and every other country in the sample, with weights equal to the log of aggregate GDP of the other country. The rationale for the use of this instrument draws on the results of gravity models (Frankel and Rose, 2002). In the typical gravity model, the intensity of trade between any two countries is decreasing in their distance and increasing in their economic size. Therefore, more distant and economically smaller countries are expected to trade less than closer and bigger countries. This implies that, in aggregate, the more distant from large economies country i is, the smaller its degree of trade integration should be. There are, of course, other exogenous determinants of trade integration that might work well as instruments. A simple option would be to use some summary measure of physical connectivity with the rest of the world. A typical example is a dummy variable for landlocked countries. However, as discussed below, the landlocked status appears to affect per-capita income not just through its effect on trade integration, meaning that one of the conditions for a valid instrument is likely to be violated. Another option is to fit a fully fledged gravity equation to obtain predicted trade shares for each country. As a matter of fact, some sensitivity checks using the predicted trade shares from Frankel and Romer (1999) was conducted. Results were largely unaffected, but specification tests indicated that the predicted shares performed marginally less well as instruments than the measure of remoteness. Finally, the equation-by-equation estimates reported below indicate that the genetic similarity between country i and the rest of the world significantly affects country i's degree of trade integration. Drawing on this result, a measure of genetic distance is used as an instrument (in addition to remoteness) in the system estimation.

The instrument for education is the degree of ethnic fragmentation. Several papers have indeed highlighted the adverse effects that ethnic fragmentation is likely to have on the supply of public goods and services, including education (Easterly and Levine, 1997; Alesina et al. 1999 and 2000). However, ethnic fragmentation may also affect other determinants of income. For instance, in Easterly and Levine (1997), but also in La Porta et al. (1999), ethnicity significantly drives institutional quality. Similarly, Fearon and Laitin (2003) show the important role of ethnicity in determining the onset of insurgency. These results would invalidate the exclusion restrictions implied by the use of ethnic fragmentation as an instrument for education. In fact, in the specific case of the sample used in this paper, ethnic fragmentation seems to be a good instrument for education. All the specification tests (see below) suggest that, when instrumented by ethnic fragmentation, education is identified (and not just weakly identified). More importantly, ethnic fragmentation is not significant in a regression of institutional quality and is also not significant in a regression of the war variable on geographical characteristics, per-capita GDP, and other potential determinants of conflict[11] . This lack of significance in turn confirms that the exclusion restrictions are most likely valid.

To assess the validity of the instruments, several diagnostic tests are reported. The LM version of the Kleibergen-Papp *rk* is used to perform a test of identification in the presence of non i.i.d. errors. Under the null hypothesis, the matrix of reduced form coefficients on the excluded instruments has rank equal to the number of endogenous regressors minus one and hence the model is underidentified. Rejection of the null indicates that the matrix is full column rank and hence that the equation is identified (see Kleibergen-Paap, 2006). The Hansen J statistic performs a test of overidentifying restrictions. The null hypothesis is that the instruments are uncorrelated with the error term and that the exclusion restrictions implied by the choice of instruments are correct. Non rejection of the null can be therefore taken as evidence that the instruments are exogenous and valid (see Hayashi, 2000 for further discussion). Lastly, the Angrist-Pischke first-stage chi-squared and F statistics are tests of underidentification and weak identification, respectively, of individual endogenous regressors. The null hypothesis is that the particular endogenous regressor is underidentified (chi-squared statistic) or weakly identified (F statistic). Rejection of the null therefore provides further support to the instrument selection (see Angrist and Pischke, 2009). Critical

[11]Results are available from the author upon reqeust.

values for the F statistic are not available, but it can be compared against the critical values computed by Stock and Yogo (2005). Alternatively, one can refer to a commonly cited rule of thumb that the F statistic should be greater than 10 for weak identification not to be a problem.

3. Equation-by-equation estimates

This section presents the results obtained from 2SLS applied equation-by-equation. Throughout this section, the lag parameter r is set equal to zero. Dynamic specifications are estimated in the next section.

3.1 Income equation

The estimates of the income equation (7) are reported in Table 1. This is in fact the type of reduced form equation that most papers estimate to assess the economic cost of civil conflict. However as stressed in Section 2, the estimated coefficient of the war variable in this equation only captures the residual direct effect of conflict; that is, the effect after controlling for the impact of the other deep determinants. The reduced form equation therefore does not provide any information on the indirect effect that conflict has on income through its effect on the deep determinants.

Column I of Table 1 reports the baseline model, with the institutional variable instrumented by malaria ecology. Geography is captured by a measure of distance from the equator. It appears that both institutional quality and education positively affect per-capita income. Trade integration and geography instead do not seem to matter. This "primacy" of institutions is indeed in line with previous findings reported by Rodrik et al. (2004). The residual direct effect of civil war is negative, significant, and economically quite large:

one additional year of war that causes 1000 battle related deaths[12] reduces the average per-capita GDP in the quinquennium by about 8%. The diagnostics tests reported at the bottom of the table generally indicate that the instruments are valid.

The other columns extend the baseline estimates in various directions. In Column II, the set of geographical variables is enlarged to include a dummy variable for landlocked countries and a dummy variable for high natural resource intensity. Both these new variables are strongly significant. Of particular interest is the positive coefficient of the resource intensity dummy as it implies that natural resources are likely to be a blessing rather than a curse. This finding is consistent with the recent evidence on the development impact of natural resources (see Brunnschweiler and Bulte, 2008 and Alexeev and Conrad, 2009). The coefficients of the other variables of the equation are not qualitatively changed. In particular, the coefficient of the civil war variable is practically the same as in Column I. In Column III, institutional quality is instrumented by legal origins rather than malaria ecology. While the estimated coefficients of all the regressors are qualitatively very similar to those in Columns I and II, the null hypothesis of the test of overidentfying restrictions is rejected at the 10% confidence level (but not at the 5% and 1% confidence levels). In Column IV both instruments (malaria ecology and legal origins) are used and again the Hansen J statistic is not particularly satisfactory. This is taken as evidence that statistically malaria ecology appears to work better than legal origins as instrument for institutional quality.[13]

INSERT TABLE 1 ABOUT HERE

[12]Because the war variable consists of duration and number of deaths, the marginal effect must be referred to both a duration measure (one year) and a death toll measure (1000 deaths). The number of 1000 deaths is used because this is the average death toll in war torn countries in this sample. That is, when a civil war occurs, on average it causes about 1000 deaths per year in this sample.

[13]The income equation was also re-estimated with institutions instrumented by the settler's mortality rate of Acemoglu et al. (2001). Results are available upon request. In a nutshell, the coefficients of all variables are similar to those in Column I. The Angrist-Pischke F statistics is however slightly smaller than 10, which might indicate a weak instrument problem.

An obvious generalization of equation (7) should allow for mean reversion in per-capita income:

$$y_{it} = \alpha + \rho y_{it-1} + \sum_{r=0}^{R} \beta_r w_{it-r} + \mathbf{z}'_{it}\boldsymbol{\gamma} + \mathbf{h}'_{y,it}\boldsymbol{\delta}_q + \varepsilon_{it} \tag{12}$$

Equation (12) is equivalent to a growth regression with a conditional convergence term. In fact, it should be noticed that instrumental variable estimation of the equation (7) still leads to a consistent estimate of the coefficient of the civil war variable, β, as long as the instruments of civil war are uncorrelated with the error term. Nevertheless, for completeness, Table 2 shows estimates of equation (12). The estimated coefficients in Column I are obtained from 2SLS with the same instruments as in Column I of Table 1. The coefficient of the civil war variable is still negative, quantitatively very similar to the estimates in Table 1, but now significant only at the 10% confidence level. Perhaps more importantly, the weak identification statistics is quite low, which suggests caution in interpreting these estimates.

Column II and III of Table 2 instead report estimates of (12) obtained from the GMM procedure of Arellano and Bover (1995) and Blundell and Bond (1998) (ABBB-GMM). As is well known, this ABBB-GMM procedure involves taking first differences of equation (12) and then estimating the level equation and the first-differenced equation jointly. Endogeneity is dealt with by using the lagged values of the first differences as instruments in the level equation and the lagged levels as instruments in the first-differenced equation. A key identifying assumption is that the errors in levels are not serially correlated, which in turn means that there should be no autocorrelation of second error in the first-differenced errors.[14]

A test of autocorrelation is reported at the bottom of the Table. In Column II, all the

[14]By construction, there is going to be first order autocorrelation in the first-differenced errors. However, if the errors in levels are not serially correlated, then the second order autocorrelation of the first differences should be statistically insignficant.

variables have the expected sign and pass a zero restriction test at usual confidence levels. There is however evidence of non-zero second order autocorrelation in the first-differenced residuals. Consequently, in Column III the model is re-estimated allowing for two lags of the dependent variable. The estimates are qualitatively similar to those presented in Column II, but the null hypothesis of no autocorrelation of second order now cannot be rejected. Also note that the Hansen J test indicates that the overidentfying restrictions are valid in both Columns II and III. The bottom line is that even when allowing for mean reversion, civil war has a residual negative effect on per-capita income after controlling for various other deep determinants.

INSERT TABLE 2 ABOUT HERE

3.2 Institutional quality equation

2SLS estimates of equation (8) are shown in Table 3. To start with, Column I presents a very parsimonious specification. In addition to the civil war variable, the model includes the index of malaria ecology and distance from the equator. The theoretical rationale for the use of malaria ecology follows from the argument of Acemoglu et al. (2001) discussed in Subsection 2.4. The latitude of a country instead has been previously used in regressions of institutional quality to control for generic geographical effects (see La Porta et al.1999). The equation is exactly identified, since the civil war variable is for now instrumented only by the log of country area. The estimated coefficients indicate that a worse malaria ecology effectively reduces the quality of institutions. The effect of civil war is negative and significant, albeit economically not very large: one additional year of civil war that causes 1000 battle related deaths reduces the measure of institutional quality by just a bit more than 2 percentage points. Measured at the sample average of institutional quality, this effect implies a decline in institutional quality of about 4.5%. However, given the estimated coefficients in Column I of Table 1, this translates into a further decline of about 7% in per-capita GDP. The diagnostic tests seem to indicate that the equation is neither unidentified nor weakly identified.

In Column II, the set of regressors also includes dummy variables for legal origins. Following the argument of La Porta et al. (1995), five different legal origins are coded: English, French, Scandinavian, German, and Socialist. The English common law was originally established as a tool to protect the Parliament and the citizens from the abuse of power of the Crown. Therefore, countries in this legal tradition should, other things being equal, have stronger enforcement of property rights and contracts. A similar argument can be made for countries in the German and Scandinavian legal origin. Conversely, the French civil code was more of a tool for the State to take greater control of economic activities, which would imply weaker institutions. Finally, the socialist law, which was explicitly aimed at enforcing State's control of the economy, should produce weakest institutions. The estimated coefficients of the dummy variables are all significant and confirm the theoretical predictions. The coefficients of the malaria ecology index and the civil war variable are qualitatively unchanged. The inclusion of other instruments for civil war does not alter these results. Estimates are reported in Column III and all of the tests support, once again, the identification strategy.

The equation has also been estimated including two other possible determinants of institutional quality (results are not reported in the table to save space, but are available upon request). One is the settlers' mortality rate. Its correlation with the malaria ecology index is high and this in turn generates a multicollinearity problem. In fact, when excluding malaria ecology, the coefficient of settler's mortality is negative and highly significant. But when malaria ecology is also included, then settler's mortality becomes insignificant, while malaria ecology is significant at the 1% confidence level. This piece of evidence is consistent with what previously reported about the superior statistical performance of malaria ecology as an instrument for institutions in the income equation. The other potential determinant of institutional quality is ethnolinguistic fractionalization. However, when entered in a regression that also controls for malaria ecology and/or legal origins, this variable always fails to pass a zero restriction. This supports the choice of not using ethnicity to instrument institutional quality in the income equation.

INSERT TABLE 3 ABOUT HERE

3.3 Education equation

Table 4 presents the 2SLS estimates of the education equation (9). The baseline model controls for two factors that previous theoretical and empirical literature indicates as key determinants of public goods provision: ethnic fragmentation and (the log of) population density. Ethnic diversity increases the likelihood of free-riding and reduces the amount of taxes that individuals are prepared to allocate to the supply of public goods. A negative relationship between ethnic fragmentation and public goods is reported in the literature for various types of public goods, including education (see Easterly and Levine, 1997; Alesina et al. 1999; Miguel and Gugerty, 2005). The effect of population density instead is more ambiguous (see, Ladd, 1992 and Hortas-Rico and Sole-Olle, 2010). On the one hand, a higher population density should increase the cost of publicly provided goods and reduce the value of receiving them. On the other hand, economies of scale may lead to declining average supply costs in large and densely populated areas.

Clearly, having included population density as a regressor, land area (which is the denominator of population density) cannot be used as a valid instrument for civil war. Therefore, in Column I, civil war is instrument by the elevation difference variable and the equation is exactly identified. The negative effect of ethnic fragmentation is large and highly significant, supporting the use of this variable as an instrument for education in the income equation. Conversely, neither civil war nor population density seem to matter. In Column II the set of regressors is extended to include a dummy variable for resource intensive economies. Because the resource sector is generally not intensive in skilled labour, return on education in resource rich economies is low and hence individuals have less incentive to attend school. The negative estimated coefficient of the dummy variable confirms this hypothesis. At the same time, the coefficients of the other three variables do not significantly change.

While the diagnostics of identification and weak identification are satisfactory, one might suspect that the lack of significance of the war variable could be related to the fact that land area cannot be used as an instrument. Luckily, population density appears to be insignificant in both Column I and Column II. Therefore, it can be dropped from the equation without running into an omitted variable problem. This in turn allows civil war to be instrumented by land area. The estimates of this new version of the education equation are reported in Column III. The coefficient of the civil war variable still does not pass the zero restriction test, meaning that civil war has a negligible effect on education. As discussed in the next section, introducing lags of the civil war variable does not modify this finding. In conclusion, it would appear that no negative effect of civil war on per-capita income is transmitted via education.

INSERT TABLE 4 ABOUT HERE

3.4 Trade equation

Table 5 reports the 2SLS estimates of the trade equation (10). In addition to the civil war variable, the regression includes the measure of remoteness discussed in Section 2 and other geographical controls. Given that the remoteness variable already accounts for physical distance, the two remaining geographical dimensions that are likely to matter are size and access to the sea. Column I presents the model that includes land area as the relevant geographical variable and civil war is instrumented by elevation difference. The remoteness variable has the expected negative coefficient, significant at the 1% confidence level. This confirms the relevance of remoteness as an instrument for trade. Civil war has the expected negative effect on trade: one additional year of civil war that causes 1000 deaths reduces average trade by about 6 percentage points of GDP. Evaluated at the average of trade, this effect corresponds to a decrease in trade integration of about 9%. Note however that because trade integration is not significant in the income equation, this trade-reducing effect of civil war is likely to have only negligible effects on per-capita income.

Given that land area is not significant in Column I, it can be dropped from the list of regressors and used as an additional instrument of civil war. This overidentified equation is estimated in Column II and results are qualitatively very similar to those in Column I. The test statistics also confirm that the equation is not underidentified or weakly identified and that the instruments of war are exogenous. In Column III, a dummy for landlocked countries is introduced as a proxy for access to the sea. Its estimated coefficient implies that, everything else being equal, lack of access to the sea reduces trade by about 12 percentage points of GDP. The effect of landlockedness is therefore almost twice as strong as the effect of one year of civil war. The inclusion of the landlocked dummy variable however does not change the evidence on the role of remoteness and civil war.

Column IV shows the results of an experiment that probably deserves further attention in future research. Using data from Spalaore and Wacziarg (2009), a measure of genetic proximity between the domestic country i and every other country in the sample. This measure is the weighted average of the inverse bilateral distance between country i and each other country in the sample, with weights equal to the aggregate GDP of the other country. The expectation is that two countries with more diverse cultures and values will also trade less intensively. The evidence seems to provide at least some support for this hypothesis. The coefficient of the genetic variable is positive and significant, albeit at the 10% confidence level only. In fact, aggregating bilateral genetic distances over all countries might admittedly weaken the statistical strength of the relationship between genetic proximity and economic integration. Nevertheless, the genetic variable might be an additional valid and relevant instrument for trade integration. The results concerning the other variables are qualitatively unaffected by the inclusion of the genetic variable, even though the estimated coefficient of the civil war variable somewhat increases in absolute value.

INSERT TABLE 5 ABOUT HERE

4. System estimates

The equations of the structural model are now re-estimated using a system estimator that allows the errors across equations to be correlated. Traditionally, system estimation uses a 3SLS estimator. However, the underlying assumption that errors are i.i.d. is likely to be violated in this case. Therefore, the system is estimated using a GMM procedure that corrects for heterosckedasticity. In fact, it can be shown that the standard 3SLS estimator is a special case of the GMM estimator (see Wooldridge, 2002).

Results are presented in Table 6, for the system of exactly identified equations (corresponding to the equations in Columns I of Tables 1,3,4, and 5), and Table 7, for the system of overidentified equations (corresponding to the equations in Column II of Table 1, Columns III of Tables 3 and 4, and Column IV of Table 5). As can be seen, the equation-by-equation results are confirmed. In particular, civil war negatively affects institutions and trade, but not education. Moreover, trade is not a significant determinant of per-capita income, so that in the end the only statistically relevant transmission channel is through institutional quality. The residual direct of civil war on per-capita income, after accounting for the transmission via the other deep determinants, is negative and strongly significant. Using the estimated coefficients in Table 6 as a reference, one additional year of civil war that causes a 1000 battle related deaths reduces the five year average of per-capita income by approximately 15.5%. Of this, slightly more than 6% is due to the adverse effect of war on the quality of institutions. The remaining 9% is due to the direct effect of war on per-capita income. The coefficients in Table 7 imply marginally smaller effects: the five year average of per-capita GDP declines by approximately 14%, of which just a bit more than 5.5% is accounted for by the institutional channel. Overall, these income effects are quantitatively very close to these obtained from the equation-by-equation estimates and suggest that the institutional channel accounts for something between one-third and one-half of the total loss in per-capita income.

INSERT TABLES 6 AND 7 ABOUT HERE

The system estimated in Table 7 is then used to analyze three important extensions concerning (i) lagged effects of civil war, (ii) the spatial effects of civil war, and (iii) the inclusion of per-capita income in the other equations of the system. Table 8 reports a summary of the results concerning these extension. To avoid overloading the presentation, only the coefficients of the war variables (and of per-capita income) are shown in the Table.[15]

To start with, the first three raws of the table (panel A) provide evidence on the lagged effects ($r = 0, 1, 2$) of civil war.[16] The pattern of coefficients on the war variables is

[15]The coefficients of the other variables can be obtained upon request
[16]

quite consistent: the contemporaneous effect is negative and significant in all equations, except the education equation. Then, the one-period lagged effect is positive, smaller than the contemporaneous effect, and significant in all equations, again except the education equation. The two-period lagged effect is negative, but generally very small and significant only in the income equation. This pattern suggests two main conclusions. First, a country afflicted by a civil war suffers significant economic costs in the quinquennium during which the war occurs, but already rebounds in the subsequent quinquennium. However, in the rebound, the country recovers only about one half of the economic loss due to the war. This means that the cumulated income loss associated with a civil war remains negative even after the rebound period. Second, the economic effects of a civil war tend to become negligible after a period of ten/fifteen years from the occurrence of the war. This timeline suggests an interesting interpretation for another key finding reported in the literature on post-conflict risk (see Collier et al. 2008). This literature shows that the risk of a new conflict is very high throughout the first ten years that follow the end of a previous war, but then rapidly declines. The evidence in Table 8 suggests that the reason why it takes about a decade for post-conflict risk to decline may be that it takes about ten years (possibly a bit longer) for the bad economic legacy of the conflict to vanish. The relationship between post-conflict risk and economic cost of conflict is certainly an interesting avenue of future research.

The next two raws (panel B) of Table 8 present the evidence on the spatial effects of civil war. There are various reasons why domestic country i might be affected by a conflict happening in some neighbor country j. For instance, the war in j might disrupt trade routes

The number of lags $R = 2$ has been chosen using a general-to-specific approach. The system was initially estimated for $R = 4$, but the four-period lagged war variable was not significiant in any of the four equations. Then, the system was estimated for $R = 3$ and again the three-period lagged war variable failed to be significant in all equations. Finally, the system was estimated for $R = 2$ and the two-period lagged war variable turned out significant in at least one equation. Given the limited time dimension of the panel, setting $R > 4$ would imply that few observations are available for estimation and this in turn makes statistical inference very unreliable.

of country i or cause large movements of refugees that affect the ability of the domestic government to deliver public goods and services (including security). To capture these effects, a variable that measures the intensity of civil wars in the region is added to the r.h.s. in all the four equations of the model. For the generic country i, this variable is defined as $\sum_{j=1}^{S} w_{jt}$ where w_{jt} is the civil war variable in generic neighbor country j and S is the total number of neighbors of country i. The neighbors of country i are simply those countries that share a land border with country i. The estimated coefficient of this variable turns out to be insignificant in the three regressions of the deep determinants. In the income regression, instead, it is positive and significant, albeit only at the 10% confidence level. A tentative interpretation for this finding is that when a country falls into war, part of its entrepreneurial know-how and skills migrate to a peaceful neighbor country, so that this peaceful neighbor experiences a boost in production. Clearly, more theoretical and empirical work on this hypothesis is needed in the future.[17] At the same time, the coefficients of domestic civil war remain significant (and negative) in the income, institutions, and trade equations.

The last four raws (panels C and D) of the table are obtained from a specification of the model that includes (the log of) per-capita income as a regressor in equations (8), (9), and (10). Richer and economically more advanced countries (that is, countries with a higher per-capita GDP) might be better able to afford good institutions, to provide public education and other public goods, and to engage in international trade. Econometrically, the problem of estimating the equations with per-capita income as a regressor is to find a suitable instrument for per-capita income. The 2SLS estimates of equation (7) presented in Table 1 indicate that the dummy for landlocked country and resource abundance may be relevant, in the sense

[17]There might also be some collinearity between domestic civil war and regional civil war. Intuitively, contagion effects may imply that the domestic country is at greater risk of civil war if its neighbrous are already involved in a civil war. Empirically, however, the correlation between the two variables is not particularly strong (0.34).

that they are likely to be strongly correlated with per-capita income. However, landlocked directly affects trade and resource dependence directly affects education, so that per-capita income would have to be instrumented by different variables in different equations. An alternative identification strategy relies on the use of the lagged first difference of per-capita income as an instrument. The underlying logic is similar to the identification strategy of the level equation in the ABBB-GMM estimator. The results are reported in panel C of Table 8. As can be seen, very little changes in equations (8) and (9): per-capita GDP is not statistically significant while the coefficients of the civil war variable are qualitatively similar to those reported in Table 7. More relevant changes are instead observed in equation (10), where per-capita GDP appears to be strongly significant and its inclusion reduces the strength and statistical significance of the effect of civil war. Another way to estimate the equations with per-capita income as a regressor is to apply the ABBB-GMM estimator equation-by-equation. Results are reported in panel D of Table 8.[18] The evidence on the effect of civil war is still quite strong. In fact, these results would suggest that the adverse effect of civil war on education is also statistically significant.

5. Conclusions

The assessment of the economic cost of conflict is generally based on the estimation of a reduced form model where per-capita income is regressed on a measure of civil war and a set of other controls. However, if civil war affects per-capita income through its effect on (some of) the other controls, then this reduced form model is inadequate to provide a correct representation of the cost of conflict. Excluding from the regression the controls that are affected by civil war does not solve the problem, as it might produce an omitted variables bias. This paper takes a different methodological route and estimates a system of

[18]For the income equation, the results are the same as those reported in Column II of Table 2.

equations. Drawing on a simple motivating theory, the system models the effect of civil war on per-capita income via three possible channels: institutional quality, trade integration, and education. In addition, the system allows for a residual direct effect of civil war on income. The equations of the system are estimated first separately, using 2SLS equation-by-equation, and then jointly, using a GMM procedure. In both cases, civil war is instrumented by a set of geographical variables and diagnostics tests on the validity of this choice of instruments are presented.

Some interesting results are obtained. Civil war negatively affects institutional quality and trade integration, while its effect on education is statistically negligible. Because trade integration turns out not to be a significant determinant of per-capita income after controlling for institutions (and education), institutional quality remains the only relevant channel of transmission of the effect of civil war. However, the residual direct effect of civil war, which is the effect of civil war on per-capita income after controlling for institutions, trade, and education, is negative and highly significant. All in all, one year of civil war that causes 1000 battle related deaths reduces the five-year period average of per-capita GDP by about 15%. The institutional channel accounts for no more than one half of this effect. The rest is due to the residual direct effect. The estimates also indicate that a country afflicted by civil war in a given quinquennium rebounds relatively quickly in the subsequent quinquennium. Furthermore, any effect of civil war appears to vanish by the third (possibly second) quinquennium after the civil war. Finally, the evidence concerning the cost of a civil war and the transmission channels is robust to accounting for spatial effects of regional conflict and feedback effects of per-capita income on institutions, education, and trade integration.

From a policy perspective, the results of this paper suggest that re-building institutions is a key priority to buffer the disruptive effect of a conflict on per-capita income. From a research perspective, future work should investigate whether the residual direct effect of civil war effectively operates through the disruption of physical capital or, instead, some other mechanism is at work. Another interesting extension of this research should look into the relationship between the stabilization of peace after a civil war and the resilience of the negative effects of the civil war. The risk of a new civil war drastically declines after the post-conflict decade. At the same time, the economic effects of a civil war become statistically negligible ten to fifteen years after the war. The similarity between the two timelines suggests that there might be connections worth studying.

6. Appendix: Variables description and summary statistics.

Variable	Definition (Source)	Mean	Std.dev
civil war	Number of years of civil war times battle related deaths. Source: Uppsula/PRIO database	2.76	9.36
institutions	Contract intensive money: M2 - currency in circulation outside bank, in percent of M2 (Clague et al.1999). Source: computed from WDI data	.48	.227
education	Average number of years of schooling. Source: Barro and Lee (2010)	4.77	2.85
trade	Exports + Imports, in percent of GDP. Source: computed from WDI data	.75	.43
latitude	Absolute value of country's latitude. Source: La Porta et al. (1999)	.28	.19
landlocked	Dummy variable = 1 if country is landlocked. Source: coded from information provided in CIA World Factbook	.19	.39
Natural resources	Dummy variable = 1 if country's exports of natural resources (in percent of total exports) is greater than sample average. Source: coded from WDI data	.52	.48
malaria ecology	Index of the stability of malaria transmission. Source: Kiszewski et al. 2004	3.68	6.44
Non-contiguous	Dummy variable = 1 if country has a non-contiguous territory (i.e. an enclave separated by sea or land from the rest of the state) Source: Fearon and Laitin (2003)	.16	.36

Variable	Definition (Source)	Mean	Std.dev
elevation difference	Difference between country's highest and lowest elevation in meters. Source: Fearon and Laitin	3038	2017
land_area	(log of) land area in km^2. Source: WDI	10.73	2.42
remoteness	Average (log) distance (in 000 km) between a country and the other countries in the sample	0.91	0.24
ethnic fragmentation	Probability that two randomly selected individuals do not belong with the same ethnic group. Source: La Porta et al. (1999)	.35	.28
per-capita income	(Log of) per-capita GDP, constant US dollars. Source: WDI	7.72	1.51
legal UK	Dummy variable = 1 if country's legal tradition is English. Source: La Porta et al. (1999)	.37	.47
legal Scandinav.	Dummy variable = 1 if country's legal tradition is Scandinavian. Source: La Porta et al. (1999)	.03	.16
legal German	Dummy variable = 1 if country's legal tradition is German. Source: La Porta et al. (1999)	.03	.17
legal socialist	Dummy variable = 1 if country's legal tradition is socialist Source: La Porta et al. (1999)	.17	.38
Population density	(log of) population/area. Source: computed from WDI data	-9.12	1.62
genetic proximity	Average of the inverse of bilateral genetic distances between a country and all the others in the sample. Source: computed from data in Spalaore and Wacziarg (2009)	1.14	0.38

Note: WDI is the World Development of the World Bank (2010 issue). CIA World Factobook is the 2010 edition of the CIA World Factbook available at https://www.cia.gov/library/publications/the-world-factbook/ . The other sources are listed in the list of references.

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8. Tables

Table 1. Baseline income equation, 2SLS results

	I		II		III		IV	
institutions	3.191***		4.033***		2.878**		2.123**	
education	.356***		.296***		.335***		.384***	
trade	-.555		-.692		-.599		-.463	
war	-.083***		-.083***		-.092***		-.077***	
latitude	.277		1.304		1.185		.817	
landlocked			-.412**		-.543***		-.503***	
nat. resources			.559***		.444***		.371**	
constant	4.556***		3.938***		4.495***		4.592***	
N. Obs	484		484		484		484	
J stat (pval)	3.196 (0.2)		3.198 (0.2)		19.769(0.06)		23.710(0.02)	
LM stat.	13.319***		18.522***		13.828**		18.348***	
				First stage				
	Chi-sq	F	Chi-sq	F	Chi-sq	F	Chi-sq	F
institutions	39.28***	12.88	30.57***	9.98	38.18***	7.45	42.14***	6.83
education	33.30***	10.92	45.61***	14.89	60.73***	11.85	58.91***	12.36
trade	214.7***	70.38	129.46***	42.26	184.45***	36.00	211.17***	34.25
war	13.40***	10.15	19.96***	10.38	17.94***	10.09	20.02***	10.11
(critical value)		(9.08)		(9.08)		(10.83)		(11.12)

Notes: 2SLS with robust standard errors. Included instruments: latitude, landlocked, and natural resources. Instrumented: institutions, education, trade, war. Excluded instruments: malaria ecology, non-contiguous, elevation difference, land area, remoteness, ethnic fragmentation. In column III legal origins replace malaria ecology as excluded instruments. In column IV both legal origins and malaria ecology are added as excluded instruments. J stat os the Hansen statistic for the overidentification test of all instruments; H0 is that the overidentfying restrictions are valid; the relevant p-value is in brackets. LM stat is based on Kleibergen-Paap (2006) for the null hypothesis that the model is underidentified. First stage chi-squared and F statistics are tests of underidentification and weak identification, respectively, of individual endogenous regressors (based on Angrist and Pischke). For the F-statistic, the critical value from Stock-Yogo (2002, 2005) is reported for comparative purposes. *,**,*** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 2, Income equation with mean reversion, 2SLS results and ABBB-GMM estimates

	I	II	III
institutions	.544***	.057***	.154***
education	.054**	.010***	.006***
trade	-.146	.036*	.031**
war	-.095*	-.002***	-.001***
latitude	.204*	1.279***	.791***
landlocked	-.107***	-.183***	-.092***
nat. resources	.031	.010**	-.001
1 lag gdp pc	.849***	.862***	1.180***
2 lag gdp pc	..	..	-.291***
constant	.678***	.713***	.537***
N. Obs.	403	438	352
J stat (pval)	0.78 (0.67)	74.17 (0.87)	70.607 (0.69)
LM stat.	4.998*	...	...
AC order 1	..	-3.582***	-4.349***
AC order 2	..	-3.169***	-1.406

First Stage

	Chi-sq	F	Chi-sq	F	Chi-sq	F
institutions	34.32***	11.13	..	..	..	..
education	17.78***	5.76	..	..	..	..
trade	199.36***	64.6	..	..	..	..
war	7.12**	7.47	..	..	..	..
(critical value)		9.08	..	..	..	..

Notes: 2SLS with robust standard errors in column I. Included instruments: latitude, landlocked, natural resources, and lagged per capita GDP. Instrumented: institutions, education, trade, war. Excluded instruments: malaria ecology, non-contiguous, elevation difference, land area, remoteness, ethnic fragmentation. Arellano-Bond-Bover-Blundell two step GMM estimator in columns II and III. The AC test is the Arellano-Bond test for zero autocorrelation in the first-differenced errors. *,**,*** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 3. Institutional quality equation, 2SLS results

	I		II		III	
war	-.022***		-.018***		-.020***	
latitude	.044		-.007		-.042	
malaria ecol.	-.0133***		-.0131***		-.0134***	
legal UK	..		.147***		.141***	
legal Scand	..		.092*		.052	
legal Germ	..		.121***		.115***	
legal Soc	..		-.086**		-.073*	
const	-.603***		.535***		.556***	
N. Obs	951		951		855	
J stat (pval)	..		..		0.2 (0.6)	
LM stat.	42.99***		42.61***		28.76***	
			First Stage			
	Chi-sq	F	Chi-sq	F	Chi-sq	F
war	47.89***	47.69	47.06***	46.66	32.12***	15.89
critical value		(16.38)		(16.38)		19.93

Notes: 2SLS with robust standard errors. Included instruments: latitude, malaria ecology, and legal origins. Instrumented: war. Excluded instruments: elevation difference. In column III land area is added to elevation different. J stat os the Hansen statistic for the overidentification test of all instruments; H0 is that the overidentfying restrictions are valid; the relevant p-value is in brackets. LM stat is based on Kleibergen-Paap (2006) for the null hypothesis that the model is underidentified. First stage chi-squared and F statistics are tests of underidentification and weak identification, respectively, of individual endogenous regressors (based on Angrist and Pischke). For the F-statistic, the critical value from Stock-Yogo (2002,

2005) is reported for comparative purposes. *,**,*** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 4. Education equation, 2SLS results

	I		II		III	
war	-.0082		-.086		-.049	
ethnic frag	-4.274***		-3.167***		-3.245***	
pop density	.075		-.151		..	
Nat. resources	..		-2.004***		-1.989***	
const	6.181***		8.633***		7.669***	
N. Obs	715		616		690	
J stat (pval)	..		..		1.782 (0.18)	
LM stat.	18.321***		17.499***		20.236***	
			First stage			
	Chi-sq	F	Chi-sq	F	Chi-sq	F
war	19.63***	19.52	18.39***	18.24	21.98***	20.91
critical value		(16.38)		(16.38)		19.93

Notes: 2SLS with robust standard errors. Included instruments: ethnic fragmentation, population density, natural resources. Instrumented: war. Excluded instruments: elevation difference. In column III land area is added to elevation different. J stat os the Hansen statistic for the overidentification test of all instruments; H0 is that the overidentfying restrictions are valid; the relevant p-value is in brackets. LM stat is based on Kleibergen-Paap (2006) for the null hypothesis that the model is underidentified. First stage chi-squared and F statistics are tests of underidentification and weak identification, respectively, of individual endogenous regressors (based on Angrist and Pischke). For the F-statistic, the critical value from Stock-Yogo (2002, 2005) is reported for comparative purposes. *,**,*** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 5. Trade equation, 2SLS results

	I		II		III		IV	
war	-.063***		-.074***		-.072***		-.079***	
remoteness	-.030***		-.034***		-.0416***		-.262**	
land area	-.0162		...		..			
landlocked	..		..		-.122*		-.156**	
genetic prox							.229*	
const	1.381***		1.274***		1.364***		.991***	
N. Obs	878		878		878		878	
J stat (pval)	..		0.311 (0.57)		0.26 (0.61)		0.233 (0.63)	
LM stat.	11.255***		35.517***		36.09***		25.348***	
				First stage				
	Chi-sq	F	Chi-sq	F	Chi-sq	F	Chi-sq	F
war	11.03***	18.98	38.24***	19.03	39.16***	19.97	27.72***	21.77
critical value		(16.38)		(19.93)		(19.93)		(19.93)

Notes: 2SLS with robust standard errors. Included instruments: remoteness, land area, landlocked, and genetic proximity. Instrumented: war. Excluded instruments: elevation difference (in all columns) and land area (in columns II, III, and IV). J stat os the Hansen statistic for the overidentification test of all instruments; H0 is that the overidentfying restrictions are valid; the relevant p-value is in brackets. LM stat is based on Kleibergen-Paap (2006) for the null hypothesis that the model is underidentified. First stage chi-squared and F statistics are tests of underidentification and weak identification, respectively, of individual endogenous regressors (based on Angrist and Pischke). For the F-statistic, the critical value from Stock-Yogo (2002, 2005) is reported for comparative purposes. *,**,*** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 6. System of baseline specifications, GMM estimates

	I	II	III	IV
	Income	Institutions	Education	Trade
latitude	.082	0.042	..	..
institutions	3.034***	..	..	..
education	.369***	..	..	..
trade	-.661	..	..	..
war	-.092***	-.021***	-.004	-.052***
malaria ecol	..	-.013***	..	..
ethnic frag.	..	..	-4.289***	..
pop density	..	..	.067	..
remoteness	..	..	..	-.028**
land area	..	..	..	-0.29
N. Obs		3003		

Notes: GMM estimates with robust standard errors. To save space, estimates of the constant terms are not reported. J-statistic is 2.21, p-val 0.345.

Column I, income equation. Dependent variable log per-capita GDP. Included instruments: latitude; instrumented: institutions, education, trade, and war. Excluded instruments: land area, ethnic fragmentation, and malaria ecology.

Column II, institutional quality equation. Dependent variable: institutions. Included instruments: latitude, malaria; instrumented: war ; excluded instruments: land area.

Column III. Education equation. Dependent variable: education. Included instruments: ethnic fragmentation, population density; instrumented: war; excluded instruments: elevation difference.

Column IV. Trade equation. Dependent variable: trade. Included instruments: remoteness, land area; instrumented: war; excluded instruments: elevation difference. *, **, *** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 7 System of extended specifications, GMM estimates

	I	II	III	IV
	Income	Institutions	Education	Trade
latitude	.987	-.048	..	..
landlocked	-.457**	..	..	-.153**
nat. resources	.509*	..	-1.712***	..
institutions	3.024**	..	..	..
education	.345***	..	..	..
trade	-.785	..	..	..
war	-.086***	-.019***	-.042	-.079***
malaria ecol	..	-.013***	..	..
legal uk	..	0.143***	..	..
legal scan.	..	.062	..	..
legal ger	..	.123***	..	..
legal soc	..	.081**	..	..
ethnic frag.	..	..	-3.432***	..
remoteness	..	..	..	-.029**
genetic prox	..	..	..	.212*
N. Obs		2847		

Notes: GMM estimates with robust standard errors. To save space, estimates of the constant terms are not reported. J-statistic are as follows: 3.17 (p-val. 0.269),

Column I, income equation. Dependent variable: log per-capita GDP. Included instruments: latitude, natural resources, landlocked; instrumented: institutions, education, trade, and war. Excluded instruments: non contiguous, elevation difference, land area, ethnic fragmentation, and malaria ecology.

Column II, institutional quality equation. Dependent variable: institutions. Included instruments:

latitude, malaria ecology, legal origins; instrumented: war; excluded instruments: elevation difference, land area.

Column III, education equation. Dependent variable: education. Included instruments: ethnic fragmentation, natural resources; instrumented: war; excluded instruments: elevation difference, land area.

Column IV, trade equation. Dependent variable: trade. Included instruments: remoteness, landlocked, genetic proximity; Instrumented: war; excluded instruments: elevation difference, land area.

*, **, *** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.

Table 8 Further extensions

	I	II	III	IV
A: Lags of civil war, GMM (system)				
war	-.097**	-.048***	-.112	-.176***
war lag 1	.052*	.026**	.055	.099**
war lag 2	-.018*	-.002	-.002	-.013
B: Domestic and regional war, GMM (system)				
war (dom.)	-.098***	-.023***	-.061	-.083***
war (reg.)	.038*	.006	-.021	.017
C: Feedback income effects, GMM (system)				
war	-.076***	-.024*	-.088	-.018*
Income p.c.	..	-.002	-.766	.193***
D: Feedback income effects, ABBB-GMM (eq-by-eq)				
war	..	-001***	-.002***	-.002***
Income p.c.	..	-.008	.069***	.017*

Notes. Column I, dependent variable is per-capita income, the other regressors (not reported) are institutions, education, trade, latitude, landlocked, and natural resources. Column II, dependent variable is institutional quality, the other regressors (not reported) are malaria ecology, legal origins, and latitude. Column III, dependent variable is education, the other regressors (not reported) are ethnic fragmentation and natural resources. Column IV, dependent variable is trade, the other regressors (not reported) are remoteness, landlocked, and genetic distance. System estimates in panels A, B, and C of the table. ABBB-GMM estimates equation-by-equation in panel D. The instruments for the system estimates are the same as in Table 7. *, **, *** denote statistical significance at the 1%, 5%, and 10% confidence level respectively.